

CONFIDENTIAL**REPORT ON IR COMMUNICATION SETS**

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July 31, 1957

I Description of Units

Two infrared communication sets were received in good condition at this laboratory on loan from SCCL. Each unit contains an infrared transmitter and receiver for voice or code signals. The sets are lightweight, and were designed for portable field operation. They are battery-powered.

The transmitter unit employs a 30-watt tungsten lamp radiation source, an optical condenser with infrared filter, a galvanometer electro-mechanical modulator, and a germanium coated main projection mirror of about 6 inches aperture.

The receiver unit utilizes the main 6 inch mirror to focus radiation on a lead sulphide photoconductive cell detector. This is accomplished by a small secondary plane mirror which is flipped into position when receiving by the send-receive switch.

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The unit also contains an electron tube amplifier which serves either transmitter or receiver, depending on the position of the send-receive switch. The amplifier supplies approximately 0.1 watt to the galvanometer for full transmitter modulation.

Each unit is 12-3/8" high, 16-7/8" wide, and 7-1/8" deep, and weighs approximately 31 pounds.

II Preliminary Test

The units were tested for two-way communication over a short range in the laboratory. Speech quality was excellent, but one of the receiver units was found to have a considerably superior signal-to-noise ratio.

III Receiver Optical System

The receiver optical system was checked by observing the light pattern falling on the PbS cell detector when a 500-watt concentrated filament lamp with clear glass bulb was used as a source 100 feet from the unit. This light pattern was observed with the aid of a narrow strip of white paper which was moved about in the vicinity of the detector sensitive surface.

The pattern obtained at the PbS cell consisted of two partially diffused patches of light ~~IIIA~~ ~~IIIA~~, and this could

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not be brought to a single light spot with any possible focusing. The Eastman-Kodak PbS cell has a sensitive area of only 1 mm. by 1 mm. and it was estimated that less than 10% of the above total light fell on the cell. Both receiver units gave similar results. Moving the light source to distances greater than 100 feet did not improve the focusing. This test demonstrates conclusively the very poor optical quality of the main reflectors, for the plane surface secondary mirrors appear to be of good quality.

IV Transmitter Optical System

The six element optical condenser which focuses the source tungsten filament on the galvanometer mirror appears to be an efficient arrangement. This condenser was slightly defocused in order to avoid a sharp image of the filament on the galvanometer mirror which would result in a non-uniform output light beam. The location of the source filament with respect to the condenser is very critical, and these units could be improved if accurate bulb positioning adjustments were provided.

The infrared filter disc was removed from the condenser assembly, and its transmission characteristics were measured. The results are tabulated below:

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Wavelength in Microns	Transmission Percent
.84	2
.88	10
1.00	50
1.077	70
1.40	90

The filter transmission remains at 90% for longer wavelengths.

Light beam modulation in these units is accomplished by turning the galvanometer, in the absence of a signal, until approximately one-half the main mirror is illuminated, so that when the galvanometer is signal driven, the illumination of the main mirror varies from zero up to the point where the main mirror is fully illuminated. In a precision optical system, this modulation scheme would result in an emitted beam of uniform beam spread, but varying in intensity to correspond with the impressed modulation.

The units on hand were tested by projecting the beam on a distant wall. With the disc filter removed, there was sufficient visual illumination to permit observations to be made of the beam cross-section. With no modulation, the wall light pattern appeared as in the following sketch:

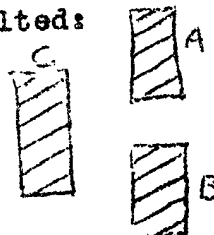
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Modulating the beam with the internal oscillator, the following pattern resulted:



Patterns A and B contained more light than pattern C.

An infrared detector and VTVM signal indicator were then used to explore the emitted beam. Light pattern B showed the greatest light modulation content. At A the signal was -3 db, while between A and B the signal was -7 db. Pattern C contained almost no modulated light. Both transmitter units gave similar results. With good optics a single light pattern with good light modulation would have resulted. Various adjustments were tried, but resulted in no further improvement.

These results confirm the very poor optical quality of the main mirrors in these sets. Professor R. A. Fisher also confirmed our conclusions about the poor optical quality of the mirrors.

With a good quality main mirror, the beam angles would be about $1/2^\circ$ horizontal by $1-1/2^\circ$ vertical. Due to the peculiar patterns obtained, it was impossible to measure the beam angles of these units.

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V Vacuum Range Test

These measurements were made with the []
[] optical attenuator, and care was taken to avoid any
loss in receiver or transmitter aperture, due to the relatively
short path-lengths employed. The unit having the best S/N
ratio was used for receiving, and care was taken to select that
section of the transmitter light beam which gave greatest light
modulation for flooding the entrance aperture of the optical
attenuator.

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The maximum range, using voice, was 5.8 miles with
no IR filter. With the filter in place, the range decreased
to 5.4 miles. With code signals, the no filter range was
found to be 6.0 miles.

The presence of the IR filter did not materially
decrease the range, because practically all of the filtering is
accomplished by the germanium coated main mirror. The filter,
however, serves to remove the last traces of visible light.

No measurements were obtained with No. 220 IR filter
because our filter disc was too large to be inserted in the
filter slot of these units.

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VI Conclusions and Recommendations

The frequency response of the galvanometers used in these units gives good response over the audio frequency range to 3000 cps. The resonance point of the galvanometer is 1500 cps. This resonance of the mirror-coil system is critically damped by oil. At 3000 cps the response is down 5 db relative to 1000 cps. This high frequency response droop can readily be made up by equalization in the modulating amplifier. The very good voice quality obtained is proof of the satisfactory response and linearity of the galvanometer.

Also, the light modulation scheme employed here is as efficient as any previously designed for use with tungsten filament light sources. It is capable of modulating one-half the incident light 100 percent. The simplicity and inherent ruggedness of the equipment lends itself readily for use in light weight apparatus designed for field use.

The present units are inferior solely because of the poor optical quality of their main reflectors.

A system employing the same modulation scheme could be devised, which would yield greatly increased range, or for the same range, smaller diameter lenses or mirrors would suffice. A similar transmitter employing a 2-inch aperture lens of fair

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optical quality was made in this laboratory, which gives 6.0 miles vacuum range. This unit will be described in the Sixth Quarterly Report of this project. The use of a lens rather than a mirror is advantageous because there is no light loss due to blocking by the galvanometer and its magnetic field structure.

For best results, separate reflectors or lenses should be used for reception and transmission.

A reflector is highly satisfactory for the receiver because the light blocked by the small PbS cell detector is negligible. This mirror should be of good quality (commercial precision) so that all of the incoming light falls on the sensitive area of the photocell. The area of the detector cell can be selected to yield the desired receiver beam angle. The receiver mirror should be front-coated with a good reflector of infrared light, such as aluminum, and no filter should be used over the PbS detector, even for daytime use.

As pointed out above, a lens can be used to advantage to project the transmitter beam. An IR filter should be employed with the transmitter to give the required degree of system security. The size of the galvanometer mirror, and the focal length of the light condensing system determines the transmitter beam angle. This beam angle can be increased

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without much loss in total radiation, by use, as required, of a beam spreading lens. However, it should be noted that increasing the beam angle results in decreased maximum communication range.

Another benefit resulting from separate mirrors or lenses for transmitting and receiving is the possibility of duplex operation. In this way, the operator transmitting can be interrupted, at will, by the receiving operator, so that the optical system would operate similarly to the regular telephone service.

VII Report Prepared by:

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Project Director

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